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A Multi-Criteria Ranking Algorithm Based on the VIKOR Method for Meta-Search Engines

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***Abstract*— Ranking of web pages is one of the most important parts of search engines and is, in fact, a process that through it the quality of a page is estimated by the search engine. In this study, a ranking algorithm based on VIKOR multi-criteria decision-making method for Meta-Search Engines (MSEs) was proposed. In this research, the considered MSE first will receive the suggested pages associated with the search term from eight search engines including, Teoma, Google, Yahoo!, AlltheWeb, AltaVista, Wisenut, ODP, MSN. The results, at most 10 first pages are selected from each search engine and creates the initial dataset contains 80 web pages. The proposed parser is then executed on these pages and the eight criteria including the rank of web page in the related search engine, access time, number of repetitions of search terms, positions of search term at the webpage, numbers of media at the webpage, the number of imports in the webpage, the number of incoming links, and the number of outgoing links are extracted from these web pages. Finally, by using the VIKOR method and these extracted criteria, web pages will rank and 10 top results will be provided for the user. To implement the proposed method, JAVA and MATLAB languages are used. In the experiments, the proposed method is implemented for a query and its ranking results have been compared in terms of accuracy with three famous search engine including Google, Yahoo, and MSN. The results of comparisons show that the proposed method offers higher accuracy.**

***Keywords*— ranking, search engines, meta-search engine, multi-criteria decision-making, VIKOR method.**

I. Introduction

At the same time as the birth of the Web, the world has seen tremendous changes in the area of data storage and retrieval. Every day the number of web pages is added and a large amount of information on the Web, in the form of a decoupled structure and free from content control is released. That's why today the problem of data retrieval is one of the most important issues in the field of web space studies. Different tools have been developed to solve this problem; the most effective and most popular information retrieval tool was the search engines. Surely the search engines have the main role to save time and money of users and the more users have skill in working with them, this role will be greater [1].

With the growth of networks and knowledge base networks as well as the widening of the information domain on the Internet, using only one specific search engine is not recommended in some circumstances, and this is due to the search engine database limitation and the nature of the Internet-based information. So, using the results of two or more search engines can partly provide access to information resources. Currently, there are search engines called the "Meta-Search Engines (MSEs)" that provides the service to users. MSEs are actually a kind of search engines that do not have a database itself, but it sends search term to databases maintained by other search engines and delivers the results they get to users. With the use of MSEs, users no longer need any single search engine to refer to and perform independent searches. Therefore, it can be argued that MSEs are one of the tools that make explicit exploration possible using Boolean operators and other search operators. Some features, such as advanced search, auxiliary guide, Adult Filter, are important in most search engines were provided in most MSEs. The EZ2Find is one of the famous MSEs that gets the result of a search from other search engines such as AlltheWeb, Teoma, Google, Yahoo!, AltaVista, Wisenut, ODP, and MSN, analyses them, eliminates duplicates, and finally displays the most relevant pages in your search results [2-4].

One of the key elements for sorting search results into search engines and MSEs is ranking. The purpose of ranking web pages is to find pages that are related to each other. The ranking is a technique by which you can discover the link between web pages. Because of the large amount of information on the Web, usually a large number of documents are found in return for any user queries and on the other hand, experience has shown that users only have 10 to 20 first results, and if they do not reach their goal or query they change their mind or skip the search. Hence, ranking is one of the key issues in designing search engines and MSEs. Each search engine has its own special algorithm for ranking and, given the importance and priority of ranking factors, there may be a different search result [1, 3].

In this paper, we propose a webpage ranking algorithm for MSEs. In the existing algorithms, few criteria (such as the number of repetitions of the search term, the title of the webpage and the age of the webpage) have been used. But in the proposed algorithm, there are additional criteria such as the number of input links, the number of the output links, the density of the search phrase on the webpage, the number of images and media on the webpage, and so on are also used for ranking operations. Also, in the proposed algorithm, the VIKOR method [5] is used to decide on the ranking of web pages.

The rest of this paper is organized as follows. Section II presents related work, the VIKOR model, and the proposed method. Section III presents the simulation results. The paper is concluded in Section IV**.**

II. Material And Method

In this section, we first present some existing algorithms which have been proposed to page ranking. Then, we present the VIKOR model. Finally, the proposed method is presented.

A. *Related Work*

In [1], the exploration of past data and the domain of knowledge have been used to design a personal information researcher. In this way, based on user profiles and domain knowledge, the system continually maintains user profiles. This improved user profile is then used to suggest web pages linked to the user.

In [3], an intelligent MSE is proposed to effectively retrieve web documents. In designing this MSE, a ranking algorithm is used that relies on the domain of web pages namely in webpage rankings, the main focus is on the degree of popularity of webpage domains.

In [4], the genetic algorithm is used to integrate multiple search engine search results. This algorithm has been used in the design of MSE to combine search results from different search engines with different rankings and perform global rankings.

In [7], comparing the time on web search engines and MSE, it was concluded that the real-time and location-specific query conditions and highlighting query conditions when viewing documents significantly improved the search efficiency on the Web.

In [8], an MSE has been programmed with the help of a language called T to create a broker for resources and to modify results. This MSE has features such as a tool for automatically testing various algorithms and some query modification schemes using a real-time HTTP-based application or script.

In [9], an MSE is designed that can communicate with the advanced heterogeneous platform web services. In [10], with the focus on the basic structure of the system of MSE and key technologies in their modules, it has been concluded that MSEs can solve the disadvantages of search engine searches to a satisfactory level.

In [11], a cluster information recovery engine is designed whose main task is to organize documents in user request and query groups, and its main purpose is to help manage information in an efficient way. This MSE is a good way to manage information that has more than one ranking list of documents.

In [12], a formal description of the query capabilities of heterogeneous search engines and an algorithm for mapping a query from a general mediator format into the specific wrapper format of a specific search engine has been proposed. The contribution of this study is that it offers a data model that is both expressive enough to meticulously describe the query capabilities of current World Wide Web search engines and flexible enough to integrate them efficiently.

In [13], an MSE called "Guided Google" by using distributed Google web services has been provided, which supports searches based on "Combined Keywords" and "Search by Host", and the results indicate an increase in Google's capabilities through scheduled service.

In [14], the related degree between the position information of query results and the query words and the similarity between query results' snippets and the query words have been integrated in order to improve the precision of meta-search engine.

In [15], using fuzzy sets and designing a clustering algorithm and managing this approach on the architecture of the search engines, the authors concluded that the method is superior to other methods.

In [16], a multifunctional architecture is introduced to customize the search engine using the fuzzy concept network. Their main goal is to use the fuzzy concept of automated networks to personalize the results of the meta-analyses provided with multi-functional architecture and speed up data retrieval.

In [17], the authors also present a hybrid ranking method that combines several ranking algorithms, and the results show a dramatic improvement in the proposed combination method compared to other algorithms. In [18] also ranked URLs that were retrieved by the MSE. This method was compared with various search engines and concluded that the design of the method is based on increasing the reliability of the results retrieved by the MSE. Also, in [19-26] algorithms based on various mechanisms such as anthology and non-regulatory algorithms, and etc. are presented for ranking web pages.

B. *VIKOR Method*

S. Opricovic had developed the basic ideas of VIKOR in his Ph.D. dissertation in 1979, and an application was published in 1980. The word VIKOR is derived from a Serbian phrase and means "Multi-criteria Optimization and Compromise Solution". The VIKOR method is one of the most widely used models in deciding and choosing the best option. This model is based on a collective agreement method with countermeasures and is generally used to solve discrete issues. This methodology is developed for multi-criteria optimization of complex systems. This method focuses on the selection of a set of items and determines compromise responses to an issue with conflicting criteria, which enables decision-makers to reach a final decision. Here, the compromise answer is the closest justifiable answer to the ideal answer, which is the word "compromise" as an interconnected agreement. In fact, the VIKOR method chooses items by evaluating them based on criteria prioritization or ranking [6] [5].

The VIKOR model consists of three main levels:

I. The first level is the subject or target.
II. The second level is the evaluation of items.
III. The third level is the items.

In fact, the VIKOR model prioritizes or rating items by evaluating them based on criteria. In this model, the criteria are not weighed, but the criteria are evaluated through other methods, and then the items are evaluated and ranked according to criteria and combined in the value of the criteria.

The main advantage of the VIKOR model is that it is not necessary to use experts' opinions to evaluate items on the basis of criteria, but to use raw data. For example, in the benchmark of communication, in order to be evaluated, for example, which village has favorable conditions, instead of scoring by experts, it is possible to measure the distance of communication to the village and enter it in the model without requiring an undergraduate assessment. This is the main difference of this model with hierarchical analysis and network analysis methods that were designed based on paired comparisons of criteria and items. While there are no paired comparisons between criteria and items in this model, each option is independently evaluated based on each criterion. This assessment can be based on raw data or based on expert opinion. Therefore, the main purpose of this model is to determine the weight and value of each item and their ranking [6] [5].

Another advantage of the VIKOR method is that there is no need for complicated software in this method, and even though it uses mathematical formulas at all stages, it can even use Excel to advance the goal.

C. *The Proposed Algorithm*

The main idea of the proposed method is to provide a webpage ranking algorithm using the VIKOR multi-criteria optimization method for MSEs. When a user places an expression in an MSE, the search engine sends the search term to a number of other search engines. Each of these search engines searches the corresponding term in its database and returns related pages to the MSE in accordance with their own ranking model. In the next step, this MSE will need to rank pages from all search engines and submit them to the user. At this point, the proposed method is used. In the proposed method, the MSE ranked the pages received from search engines again based on several criteria and with the help of the VIKOR method. The criteria considered in the proposed system are:

- The rating assigned by the search engine to the considered webpage.
- Time to access the webpage.
- The number of times a search phrase is repeated on the webpage.
- The position of the search phrase on the webpage, if the search term exists in the title of the webpage, the value of this criterion is 2, otherwise, the value of 1 is given.
- The number of media on the webpage
- The number of Imports used on the webpage.
- The number of output links from the webpage.
- The number of incoming links to the webpage.

A flowchart of the proposed method is presented in Fig. 1. The following describes the steps of the proposed method based on this flowchart.

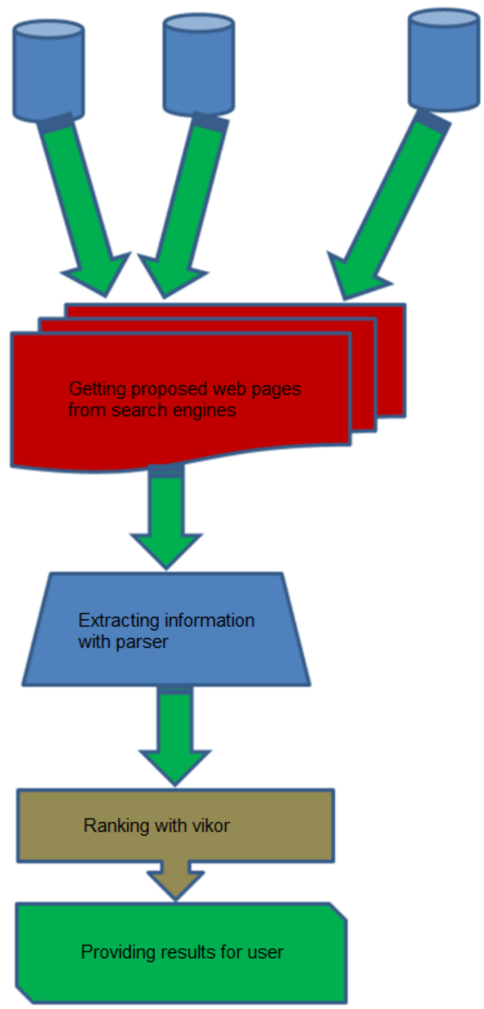

Fig. 1 A flowchart of the proposed method

Getting suggested pages from search engines: At this point, the suggested pages are collected by each search engine for a search term (for example, “VIKOR”). The suggested pages are ranked by each search engine based on their specific criteria and mechanisms. It is assumed that the MSE will use the results of the eight AlltheWeb, Teoma, Google, Yahoo!, AltaVista, Wisenut, ODP, and MSN search engines. Each of these eight search engines independently explores its database to find pages related to the phrase "VIKOR". The MSE integrates the results of the eight search engines and merges them. At this point, for each search engine, a maximum of 10 first pages, which have the highest rank in their search engine, are selected (10 first pages of each search engine's results). At this point, a dataset containing up to 80 web pages is created.

Extracting information by the proposed parser: At this stage, the dataset collected in the previous step, the file containing the 80-page address associated with the user-search term is injected into the proposed parser as an input. The proposed parser is trying to extract the necessary information from these web pages to meet the desired criteria. The proposed parser in JAVA language has been designed and implemented. The steps of the proposed parser are as follows

I. **Removing duplicate pages**. Since a webpage may coincide with more than one of these eight search engines as the page associated with the user search term, duplicates should be deleted in the dataset file.

II. **Connecting to the web page.** The parser first is connected to the webpage via an API function in Java named JSoup. After connecting to this web page, the information is extracted from the following criteria:

- **Time to access the webpage**: this is a measure in milliseconds and determines what is the amount of latency to connect to the web page. This criterion is by Google search engine has also been used. The time to access a web page is less likely to be awarded a higher rating.
- **The number of repetitions of the search term on the web page**: this criterion can express the importance degree of a web page with a search phrase. The repeated times of the search phrase on a web page indicates the degree of connection with the subject in the search. Hence, a higher rank can be attributed to it.
- **Position of the search phrase on the web page**: generally speaking, if the title of a web page includes a search term, can indicate the degree of relevance to the subject of the search term. Therefore, it is better to give a higher rating to this page.
- **The number of media**: The more a web page has more images and videos, it can be more appealing and useful for many users. Because most users are offering examples and video cases will find out more about a problem and, therefore, prefer to see pages that contain images, audio, or educational videos. So, the more a web page has more media content, the higher the ranking can be attributed to itself.
- **The number of Imports**: The more you use the number of Imports on a web page it can reflect the importance, credibility, and expertise of that web page. So you can rank it higher.
- **The number of output links**: Everything on a web page has a lot of embedded links, it can be a sign of its high importance. Therefore, by increasing the number of output links on a web page will be given a higher rating.
- **Donation ranking by the search engine:** Another important criterion in the proposed system is the use of the rating given by each of the eight search engines to their pages. This rating for each web page is a number from 1 to 10. The lower number represents a higher rank.
- **The number of incoming links:** Another important criterion in determining page rank is the number of links to the page. The higher the number of incoming links to a web page is, the higher it's ranking. To derive this benchmark, the tool provided by Google is available under the following: http://goohackle.com/tools/who-links-to-me/

At the end of this step of the proposed method, a final dataset file (called dataset.csv) is created that contains the octal criteria mentioned in the proposed system to each of the pages in the original dataset file.

Ranking by Vikor method: There are several different items in VIKOR model, which are independently evaluated on a multi-criteria basis and ultimately ranked by their value. In the first step, a decision matrix is formed according to criteria such as Fig. 2. The matrix of the decision is represented by *X* and its intersection with *Xij*. In the proposed ranking system, the decision matrix has *n*=8 columns (to the number of criteria) and m=80 rows (the maximum number of pages in the dataset). Therefore, the decision matrix for the proposed method is shown in Fig. 2.

TABLE II
THE VIKOR'S DECISION MATRIX IN THE PROPOSED METHOD

Items	Page ranking	Access time	Repetition number of search term	Position of search term	The number of media	The number of imports	The number of outcoming links	The number of incoming links
1								
2								
…								
….								
…								
m								

In the second stage, the normalization of the decision matrix is made according to equation (1):

$$f_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^{2}}} \quad (1)$$

Linear normalization is used in the VIKOR method. Each *Xij* is the value of each criterion for each item.

In the third step, according to the coefficient of the importance of different criteria in decision making, a weight vector is defined.

In the fourth step, for each criterion, the best and worst item among all items is determined and called f^* (the ideal positive point) and f^- (the ideal negative point), respectively.

If the benchmark is of a useful type, then

$$f_j^* = Max\,(f_{ij}),\quad f_j^- = Min\,(f_{ij}) \tag{2}$$

And if the benchmark is of a kind of loss, we will have:

$$f_j^* = Min\,(f_{ij}),\quad f_j^- = Max\,(f_{ij}) \tag{3}$$

In the fifth step, the amount of profitability and regret is determined. Two profitability (*S*) and regret (*R*) concepts are considered in VIKOR calculations. The profitability value (*S*) represents the relative distance of the ith item from the ideal positive point and the amount of regret (*R*) expressing the maximum discomfort of the ith item from the ideal positive point. Here, W_j is the amount of weight for the *j* criterion.

$$S_i = \sum_{j=1}^{n} W_j \cdot \frac{f_j^* - f_{ij}}{f_j^* - f_j^-} \tag{4}$$

$$R_i = max\left[w_j \cdot \frac{f_j^* - f_{ij}}{f_j^* - f_j^-}\right] \tag{5}$$

In the sixth step, the Vikor index (*Q*) for each item is calculated in accordance with equation (6):

$$Q_i = v\left[\frac{S_i - S^*}{S^- - S^*}\right] + (1-v)\left[\frac{R_i - R^*}{R^- - R^*}\right] \tag{6}$$

$$S^* = MinS_i\ ;\ S^- = MaxS_i$$

$$R^* = MinR_i\ ;\ R^- = MaxR_i$$

Here, $v \in [0, 1]$ depends on the decision maker's opinion, which is generally considered to be 0.5.

In the final step, depending on the values of *R*, *S*, and *Q*, the items are arranged in three groups of small to large. The superior item is the item which is selected in all three groups as the preferred item. Similarly, the second, third, and other superior items can be obtained.

It should be noted that in the *Q* group, the item is chosen as the superior to establish the following two conditions:

Condition 1: If option A1 and A2 have the first and second rank among the items, the following condition should be true:

$$Q(A_2) - Q(A_1) \geq \frac{1}{m-1} \tag{7}$$

Condition 2: Item A1 must be recognized as the top rank in at least one of the *R* and *S* groups.

III. Discussion and Simulation Results

In this section, the evaluation of the proposed method is discussed. In order to implement the proposed method, Java programming language and MATLAB software are used. The proposed parser has been implemented by the Java and for implementing VIKOR system the MATLAB software has been used.

A. *Research Dataset*

A sample query for the word "VIKOR" has been used to collect the research dataset. Initially, the word " VIKOR" was searched on each of the eight AlltheWeb, Teoma, Google, Yahoo!, AltaVista, Wisenut, ODP, and MSN engines, and then from the back pages of each of these eight search engines, Maximum top 10 pages are selected. Selected web pages are merged and constitute an 80-page web page. This file is given as a research dataset to the proposed parser and parser output as input to the VIKOR system.

B. *Evaluation Criteria*

Here, according to research [20], precision and recall are used to evaluate a search engine. But the discovery of the relevance of all documents to a search query in a search engine is difficult. Therefore, the most commonly used and most popular benchmark for evaluating the performance of search engines is the TREC-specific accuracy, which is called the TSAP. The TSAP benchmark is derived from equation (8).

$$TSAP = \left(\sum_{m=1}^{L} record_m\right)/L \tag{8}$$

Where $record_m$=1/m if the ith ranked result is relevant and $record_m$ = 0 if the ith ranked result is not relevant. Also, *L* is the number of pages selected by the search engine to deliver.

The manual method is used to determine the relevance of a web page with the requested query. That is, the web page is loaded and it is checked whether this web page is relevant to the query or not.

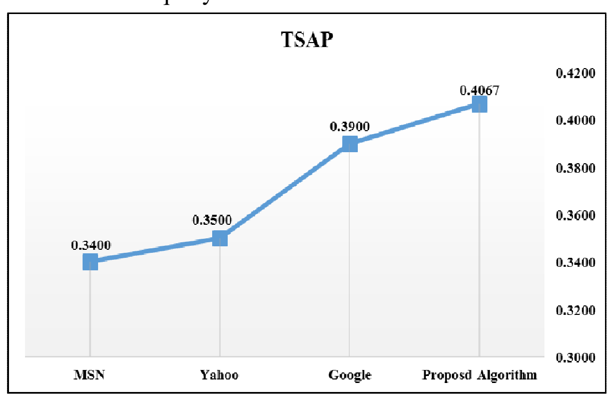

Fig. 3 Compare the efficiency of the proposed method with other search engines in terms of the TSAP, for *L*=5.

C. *Experiment Results*

Here's how to evaluate the TSAP of the proposed method and compare results with Google, Yahoo, and MSN. The results of the comparisons are depicted in Fig. 3 for *L*=5, Fig. 4 for *L*=10, and Fig. 5 for *L*=15.

The results of the comparisons in Fig. 3 show the accuracy of the proposed method (TSAP) in the ranking of pages is 0.4067, while the rate for Google is 0.39 and for Yahoo and MSN is 0.35 and 0.34, respectively.

Also, Fig. 4 shows the results of the comparisons for L=10. In this assessment, the accuracy of the proposed method in the ranking is 0.2579, while the rate for Google, Yahoo, and MSN are 0.2453, 0.2153, and 0.201, respectively. Similarly, Fig. 5 shows that in the choice of L=15, the proposed algorithm has a precision of 0.1880, while for the other three search engines, this rate is less than 0.18.

The results of the evaluations showed that by increasing L, the search engine shows more pages as a result to the user, the accuracy rate decreases.

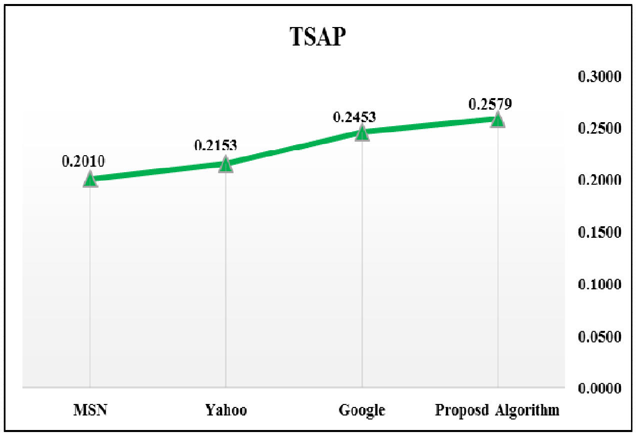

Fig. 3 Compare the efficiency of the proposed method with other search engines in terms of the TSAP, for L=10.

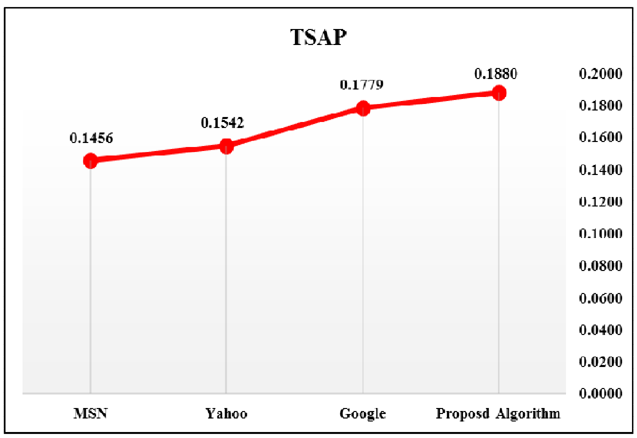

Fig. 3 Compare the efficiency of the proposed method with other search engines in terms of the TSAP, for L=15.

IV. Conclusion

In this paper, a new method for ranking web pages in meta-search engines was proposed. To implement the proposed method, a multi-criteria optimization model was used. The proposed method also uses an online parser to extract eight effective metrics from web pages selected from search engines. The VIKOR method is then used to rank web pages based on these eight criteria. The proposed method was run for a typical query and its ranking results were compared with the three well-known Google, Yahoo and MSN search engines in terms of accuracy. The results of the comparisons showed that the proposed method offers higher accuracy.

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